ERDC/CRREL TR-17-11

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Examining Wetland Frequency Discrepancies Produced by Data Collected at Wetland Boundaries and across the Landscape

Using *Tsuga canadensis* (L.) Carr. (Eastern Hemlock) as a Case Study

Robert W. Lichvar and Jennifer J. Goulet

August 2017

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Abstract

This study examined two types of data for determining a species' wetland frequency and rating during rating-change-request challenges to the National Wetland Plant List (NWPL). *Tsuga canadensis* (L.) Carr., a species with a problematic wetland rating, was used as a case study. *Boundary* data were collected on wetland boundaries during delineations by Corps regulators and private consultants, and *Landscape* data were collected across the landscape during vegetation research projects by the Cold Region Research and Engineering Laboratory team. This investigation compared the wetland frequencies and ratings produced by Boundary data and Landscape data across a large and a moderately large study area. In both study areas, the Boundary data produced a higher wetland frequency (36%–40%) and a wetter wetland rating (Facultative—FAC) than the Landscape data (15%–18%, Facultative Upland—FACU). These results demonstrate why wetland delineation data should not be used for determining wetland frequency and ratings during challenges to the NWPL because (1) they do not represent a species' entire distribution across the landscape; (2) only dominant species are recorded on delineation data forms; (3) large, adjacent boundary plots are statistically likely to produce a FAC rating; and (4) delineation data are difficult to access from both regulatory agencies and public sector environmental consulting firms.

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Preface

This study was conducted for and funded by the U.S. Army Corps of Engineers (USACE) Wetlands Regulatory Assistance Program (WRAP) under Work Item F85509, "Testing Boundaries Landscape-Level Problematic Indicator Status." The program manager was Ms. Sally Stroupe, U.S. Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL).

The work was performed by the LiDAR and Wetlands Group (CEERD-RRC), of the Remote Sensing and Geographic Information Systems Center of Expertise (RS/GIS CX) (CEERD-RZR), ERDC Cold Regions Research and Engineering Laboratory (CRREL). At the time of publication, Dr. Elias Deeb was Chief, CEERD-RRC; Mr. David Finnegan was Director, CEERD-RZR. The Deputy Director of ERDC-CRREL was Dr. Lance Hansen, and the Director was Dr. Joseph L. Corriveau.

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Acronyms and Abbreviations

CRREL	U.S. Army Cold Regions Research and Engineering Laboratory
EPA	U.S. Environmental Protection Agency
FAC	Facultative
FACU	Facultative Upland
FACW	Facultative Wetland
FWS	U.S. Fish and Wildlife Service
ERDC	Engineer Research and Development Center
ERSI	Environmental Systems Research Institute
NAHB	National Association of Home Builders
NC	Nature Conservancy
NCNE	Northcentral and Northeast
NCNE RS	Northcentral and Northeast Regional Supplement
NP	National Parks
NRCS	U.S. Department of Agriculture Natural Resources Conservation Service
NTCWV	National Technical Committee for Wetland Vegetation
NWPL	National Wetland Plant List
OBL	Obligate Wetland
RS/GIS	Remote Sensing/Geographic Information Systems
RS/GIS CX	Remote Sensing and Geographic Information Systems Center of Expertise
UPL	Upland
USACE	U.S. Army Corps of Engineers

USGS	U.S. Geological Survey
USGS-NPS	U.S. Geological Survey National Park Service
VCGI	Vermont Center for Geographic Information
WRAP	Wetlands Regulatory Assistance Program

1 Introduction

1.1 Background

For U.S. Army Corps of Engineers (USACE or Corps) regulatory purposes under Section 404 of the Clean Water Act, wetland boundaries are delineated by using three factors: wetland hydrology, hydric soils, and hydrophytic vegetation (Environmental Laboratory 1987). To determine if plant communities are hydrophytic, vegetation is assessed using vegetation formulas, percent cover, and the wetland ratings of species on the National Wetland Plant List (NWPL). These plant species are rated based on their wetland frequency, how often each species is thought to occur in wetlands as opposed to uplands, across its entire range (Reed 1988). The National Technical Committee for Wetland Vegetation (NTCWV) recently reevaluated this definition of wetland frequency, confirming that it is a scientifically sound basis for assigning wetland ratings (NTCWV 2013). Ratings are assigned by National and Regional Panel members from four cooperating federal agencies: the Corps, the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS), and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS). Panel members receive input from professional botanists, ecologists, and other technical experts (Lichvar and Gillrich 2011). Wetland ratings are assigned using ecological descriptions of rating categories (Table 1) supported by the botanical literature, herbaria information, and the best professional judgment of botanists and plant ecologists (Lichvar et al. 2012; Lichvar and Minkin 2008). For delineation purposes, hydrophytes are plant species that have been rated obligate wetland (OBL), facultative wetland (FACW), or facultative (FAC) and are considered indicators of wetland vegetation. Nonhydrophytes are those plant species rated facultative upland (FACU) or upland (UPL). They are usually not considered indicators.

These five rating categories were originally divided into numeric wetland frequency categories (Reed 1988) even though there were no data to support or confirm the frequency with which a plant species occurs in wetlands and uplands across its entire range (Table 1). Large-scale frequency sampling and its associated financial costs have prevented the collection of frequency data for all the species on the NWPL. Therefore, the numeric frequency categories are now reserved for determining the ratings of the most problematic species (Lichvar et al. 2012). Yet, collecting plant species

occurrence data for even one species in wetlands and uplands across the landscape throughout its entire range requires a great deal of time and money. One possible alternative is to determine the wetland frequency of a problematic species by using occurrence data from existing databases. Data from existing databases might be suitable for calculating wetland frequency if they were collected using sampling methods that correspond with the definition of wetland plant frequency. The Cold Regions Research and Engineering Laboratory (CRREL) team is currently exploring methods for developing wetland ratings by using landscape-scale data collected by the National Park Service. One preliminary analysis from the Northcentral and Northeast region, suggests that landscape-scale data obtained from existing databases produces similar wetland frequencies and the same rating as data collected specifically for calculating the wetland frequency of a problematic plant species (Lichvar and Goulet 2017).

Table 1. Five categories of wetland ratings assigned to species on the National Wetland Plant List (NWPL). The ratings are used during wetland delineations to determine if vegetation is hydrophytic.

Wetland Rating	Species Designation	Qualitative Ecological Description (Lichvar et al. 2012)	Numeric Frequency Categories (Reed 1988)
Obligate (OBL)	Hydrophyte	Almost always occur in wetland	>99
Facultative Wetland (FACW)	Hydrophyte	Usually occur in wetland, but may occur in nonwetland	67–99
Facultative (FAC)	Hydrophyte	Occur in wetland and nonwetland	34–66
Facultative Upland (FACU)	Nonhydrophyte	Usually occur in non-wetland, but may occur in wetland	1–33
Upland (UPL)	Nonhydrophyte	Almost never occur in wetland	<1

The NWPL has been under the administrative direction of USACE since 2006. CRREL is responsible for maintaining the NWPL, including directing web-based updates of plant species nomenclature, geographic ranges, and wetland ratings (www.wetland-plants.usace.army.mil). During the Federal Register Comment period of the 2012 NWPL update, several commenters suggested using data collected at wetland boundaries during delineations to calculate the wetland frequency of plant species on the NWPL (NAHB 2011; Pierce 2011; St. Onge et al. 2011). One commenter suggested creating a database of the most common species in each Corps Region by using data forms from Corps-approved delineations (Pierce 2011). Wetland delineation procedures require estimates of the percent areal cover of plants

in plots on either side of the wetland boundary. Therefore, a database created from the information in delineation data forms could be used to determine the presence or absence of plant species growing in wetlands and uplands near wetland boundaries across a Corps region. Using data collected at wetland boundaries to calculate wetland frequency and assign wetland ratings seems like a simple, cost-effective way to assign ratings by using data-driven methods.

If data from other sources are to be used for challenge study purposes, the spatial scale is very important because it determines the patterns of plant frequency that an investigator detects (Wiens 1989). Spatial scale has two components, the area sampled (spatial extent) and the plot size. To detect large-scale patterns among wetland vegetation types, ecologists typically use large sample units to sample broad, heterogeneous extents, such as the province of Alberta (Vitt et al. 1995). A large-scale approach is advantageous when sampling large plants, such as trees, because the study is conducted at a spatial scale relevant to the organism (Wiens 1989). Drawbacks to this approach include overlooking small seedlings and overestimating percent cover (McCune and Grace 2002). However, accuracy can be increased by increasing sampling intensity. For instance, wetland vegetation has been sampled across a large area (two regions) by using large plots subsampled with point-intercept sampling methods (Gignac and Vitt 1990). The drawback is that this type of sampling is very labor intensive.

1.2 Objective

The study objective was to compare the wetland frequencies and ratings produced by *Boundary* data collected at wetland boundaries during delineations with those produced by *Landscape* data collected across the landscape to determine if Boundary data are suitable for calculating wetland frequency during challenges to the NWPL. *Tsuga canadensis* (L.) Carr. (Eastern Hemlock) was chosen as a case study. This species usually occurs in uplands, and it is rated FACU on the 2016 NWPL in all Corps regions in which it occurs (Lichvar et al. 2016). However, its rating is considered problematic in the Northcentral and Northeast (NCNE) region because it can dominate wetlands and may cause a plant community to fail to meet hydrophytic vegetation indicators (USACE 2012). Frequency data would help determine if *T. canadensis* occurs in wetlands 1%–33% of the time (FACU) or 34%–66% of the time (FAC).

1.3 Approach

The CRREL team obtained two types of data (Table 2). Boundary data, collected using small-scale sampling methods during wetland delineations, were gathered from Corps Regulatory Districts and environmental consultants. Landscape data, collected using large-scale sampling methods, were obtained from two sources: (1) vegetation surveys in National Parks (NP data) and (2) vegetation data collected to assess wetland frequency and to assign ratings (CRREL data).

Table 2. Characteristics of datasets used to assess wetland frequency and to assign ratings to *Tsuga canadensis* (L.) Carr. Boundary data were collected at wetland boundaries during delineations. Landscape data were collected across the landscape during vegetation research projects. The variable *n* is the number of sample units used to calculate wetland frequency.

Study Area	Dataset	Objective	Scale	Area Sampled	Plot Size
Large (~742,800 km^2)	Boundary data (All, n = 134)	Wetland Delineation	Small	Boundary (Small)	Small–Fairly Large (≤9 m radius)
Large (~742,800 km^2)	Landscape data (NP, n = 169)	Vegetation Survey	Large	Landscape (Large)	Fairly Large–Large (5 × 5 to 20 × 50 m)
Moderately large (~20,000 km^2)	Boundary data (Subset, n = 42)	Wetland Delineation	Small	Boundary (Small)	Small–Fairly Large (≤9 m radius)
Moderately large (~20,000 km^2)	Landscape data (CRREL, n = 36)	Wetland Frequency Assessment	Large	Landscape (Large)	Large (100 m transects)

Because prior work shows that wetland frequency and ratings can vary with the spatial extent of the study area (Gage et al. 2016; Lichvar and Goulet 2017), Boundary and Landscape data were gathered in two different-sized study areas. The large study area was approximately the size of the NCNE region (~742,800 km^2). The moderately large study area was approximately the size of a 6-digit HUC watershed (~20,000 km^2). In each study area, the Boundary and Landscape data were used to calculate and compare wetland frequencies and ratings. The review of the large study area compared wetland frequencies and ratings produced using all the Boundary data and the NP data (Table 2). The review of the moderately large study area compared the wetland frequencies produced using a subset of the Boundary data and the CRREL data.

2 Methods

2.1 Boundary data (small scale)

The Boundary data consisted of wetland delineation data sheets gathered from 58 project sites that were delineated for wetland regulatory purposes in the Buffalo, New England, and St. Paul Districts. All delineations were performed by regulators or environmental consultants and were approved by the Corps or the New Hampshire Department of Environmental Services. Small-scale methods were used to delineate wetland boundaries at these sites according to procedures from the *Corps of Engineers Wetland Delineation Manual* (hereafter the 1987 Manual) (Environmental Laboratory 1987) and the Northcentral and Northeast regional supplement (NCNE RS) (USACE 2012). Data were collected in large, adjacent plots across a small spatial extent on either side of a wetland boundary. Percent areal cover data were collected in nested circular plots. Cover data for trees and vines were collected in fairly large plots with a 9.1 m (30 ft) radius. Cover data for shrubs and saplings were collected in smaller plots with a 4.6 m (15 ft) radius. Cover data for herbs and woody species less than 1 m (3.3 ft) in height were collected in small plots with a 1.5 m (5 ft) radius. Percent areal cover of the dominant species in each stratum was recorded on the delineation data forms. Soil and hydrology indicators were recorded as described in the 1987 Manual and in the NCNE RS.

For this study, *T. canadensis* was counted as present if it was listed on a data form in any stratum, regardless of its percent-cover value. If it was not listed, it was considered absent. All of the Boundary data was used to calculate wetland frequency in the large study area. A subset of these data was used to calculate wetland frequency in the moderately large study area.

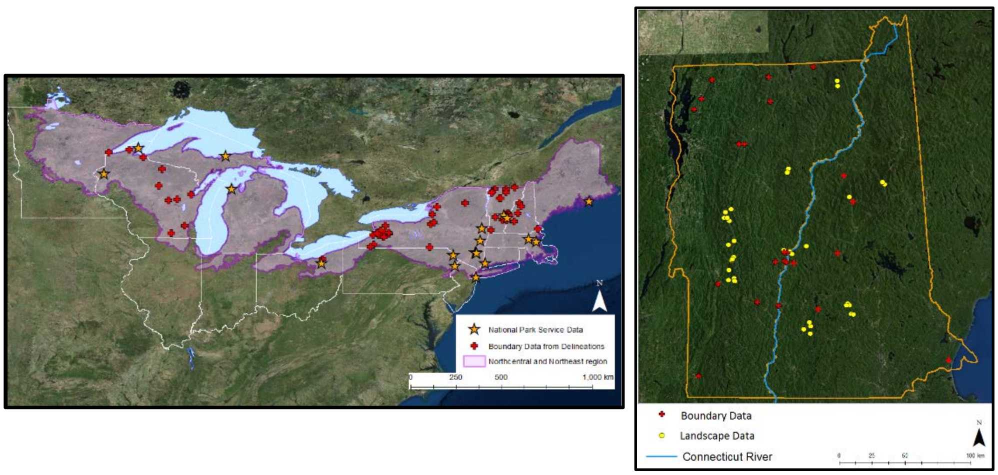
2.1.1 Large study area (742,800 km^2)

T. canadensis was present in a total of 176 pairs of wetland/upland boundary plots across the large study area (Figure 1a). To help ensure that the data were independent, 42 pairs of plots were randomly removed from these data because they occurred consecutively along the same wetland boundary. Therefore, the large study area was represented by 134 nonconsecutive pairs of wetland boundary plots. Because the upland and wetland plots in each pair of boundary plots were not independent, one-half of the

dataset was used to tally wetland occurrences, and the other was used to tally upland occurrences. Together, the wetland and upland occurrences were used to calculate wetland frequency.

Figure 1. Data-collection locations across the (*a*) larger study area of 742,800 km^2 and (*b*) moderately-large study area of 20,000 km^2.

a) b)



2.1.2 Moderately large study area (20,000 km^2)

T. canadensis was present in 50 pairs of wetland/upland boundary plots in the subset of the Boundary data used to assess wetland frequency in the moderately large study area (Figure 1b). To help ensure that the data were independent, eight consecutive pairs of plots were randomly removed because they occurred consecutively along the same wetland boundary. The data representing the moderately large study area consisted of 42 nonconsecutive pairs of wetland boundary plots. Because the upland and wetland plots in each pair of boundary plots were not independent, one-half of the dataset was used to tally wetland occurrences, and the other was used to tally upland occurrences. Together, the wetland and upland occurrences were used to calculate wetland frequency.

2.2 Landscape data (large scale)

The Landscape data were collected by using large-scale methods. These data were collected in large sample units across a large sample area, the landscape. The NP data was used to calculate wetland frequency in the large study area. The CRREL data was used to calculate wetland frequency in the moderately large study area.

2.2.1 Large Study Area (742,800 km^2)

The NP data were collected by the U.S. Geological Survey and National Park Service (USGS-NPS). Since 1998, the USGS-NPS has collected vegetation data across National Park landscapes as part of the Natural Resource Inventory and Monitoring Program. Its goal is to classify, describe, and map the structure and species composition of plant communities in National Parks across the United States. In each park, the area sampled varied based on park size, terrain features, heterogeneity of vegetation types, logistics and cost to access, and safety considerations (NC and Esri 1994). Plot size was variable. Percent-cover data were collected in plots ranging in size from 20 × 50 m to 5 × 5 m. Cowardin wetland codes (Cowardin et al. 1979) and the designation "upland" were used to classify plots as wetland or upland. These data were downloaded from https://irma.nps.gov and used to develop a database of wetland and upland occurrences for 6331 plant species throughout the ten Corps regions (Buff and Leopold 2013). The geographic coordinates of plots were used to separate records by region.

The current study used only data collected across National Park landscapes in the NCNE region (Figure 1a). *T. canadensis* was counted as present in every plot in which it occurred (n = 259) in the 19 NCNE region parks, regardless of its size (e.g., tree or seedling) or percent-cover value. Ninety plots containing *T. canadensis* were excluded because they could not be confidently categorized as either upland or wetland based on the NP plot classification data. The number of times that *T. canadensis* occurred in uplands and wetlands was tallied from the remaining 169 plots and was used to calculate wetland frequency.

2.2.2 Moderately large study area (20,000 km^2)

The CRREL data were also collected across the landscape by using a large sample area and large sampling units. These large-scale methods were developed in conjunction with the NTCWV (for details, see Lichvar and Goulet 2017). The CRREL team created a sampling frame across ten randomly chosen watersheds (12-digit HUCS) based on descriptions of *T. canadensis* habitat (Gleason and Cronquist 1991; Hardin et al. 2001; Magee and Ahles 2007), GIS data (Table 3), and previous field experience. The sampling frame showed areas across the landscape where *T. canadensis* was likely to occur. It included (1) evergreen or evergreen/deciduous upland forests lower than 735 m in elevation that had a flat aspect or a sloped northern or

eastern aspect and (2) needle-leaved or needle/broad-leaved wetlands below 735 m in elevation. Sets of coordinates representing potential vegetation sampling locations were randomly generated in the sample frame by using the *Create Random Points* tool in ArcMap 10.1.

Table 3. Geospatial data used to create a sampling frame for *Tsuga canadensis* (L.) Carr. at the moderately large study area of 20,000 km^2.

Name	Date	Source	Website
National Elevation Dataset	2009	U.S. Geological Survey (USGS)	http://datagateway.nrcs.usda.gov
National Hydrography Dataset	2012	U.S. Geological Survey (USGS)	http://datagateway.nrcs.usda.gov
National Land Cover Dataset	2011	Multi-Resolution Land Characteristics Consortium	http://www.mrlc.gov
National Wetland Inventory	2009	U.S. Fish and Wildlife Service	http://www.fws.gov/wetlands/data
New Hampshire Public/Conserved Lands	2009	University of New Hampshire Statewide GIS Clearinghouse	http://granit.sr.unh.edu
USA Topographic basemap	2009	Environmental Systems Research Institute (Esri)	http://www.esri.com
Vermont Public/Conserved Lands (PCL)	2009	Vermont Center for Geographic Information	http://vcgi.vermont.gov

In the field, the CRREL team navigated to each set of coordinates and, if necessary, used a brief reconnaissance to determine if *T. canadensis* was present. If the species was not located in 15 minutes, the point was discarded. If *T. canadensis* was present, a wetland/upland determination was made using soil and hydrology indicators from the NCNE RS (USACE 2012). Transects were laid out in randomly chosen directions and restricted to either upland or wetland. Transects never crossed upland–wetland boundaries. Each large, 100 m transect was subsampled by using point-line-intercept sampling methods to record the presence or absence of *T. canadensis* at every meter mark. When it intercepted a meter mark, *T. canadensis* was counted as present. The canopy of trees growing on wetland boundaries was included in wetland transects only if it was rooted in the same soil type or was lower than a topographic break. Soil and hydrology indicators described in the NCNE RS (USACE 2012) were recorded as present or absent in five representative locations about once every 25 m to ensure that each transect remained either in wetland or in

upland. A maximum of 3600 occurrences of *T. canadensis* were possible as a result of sampling thirty-six 100 m transects.

In each study area, wetland frequency was calculated using the Boundary data and the Landscape data as follows:

$$\mathrm{F_{wetland}} = \left(\frac{\mathrm{W}}{\mathrm{W+U}}\right) \times 100$$

where

F = frequency,
W = the number of wetland occurrences, and
U = the number of upland occurrences.

A wetland rating was assigned to each frequency based on the numerical categories described by Reed (1988) (Table 1).

The maximum possible error in each wetland frequency calculation was estimated based on sample size by using the formula

$$\mathrm{MPE} = \mathrm{Z_{0.95}}\left(\sqrt{\frac{0.5(1-0.5)}{n}}\right).$$

This formula represents the 95% confidence level for a proportion of 0.5 where MPE is the maximum possible error, Z is the test statistic for a 95% confidence level, and *n* is the number of sample units. This formula was used because some of the data were not collected using a random sampling design, so statistical inference was somewhat limited (Buff and Leopold 2013).

3 Results

The Landscape data (CRREL and NP data) indicated that a nonhydrophytic rating of FACU is appropriate for *T. canadensis*, given its wetland frequencies of 15%–18%, regardless of the margin of error. In contrast, the Boundary data collected during delineations produced higher frequencies and wetter ratings than the Landscape data (Table 4). In both study areas, the Boundary data produced a wetland frequency of 36%–40% and a hydrophytic rating of FAC for *T. canadensis*, suggesting that it was equally likely to occur in wetland and upland. However, a rating of FACU is also possible, given the broad error estimates.

Table 4. Comparison of the wetland frequency and wetland ratings of *Tsuga canadensis* (L.) Carr. across two study areas by using Boundary data collected at wetland boundaries during delineations and Landscape data collected across the landscape. The maximum possible error is bracketed.

(a) Large Study Area (742,800 km^2)	Boundary data		Landscape data (NP)	
	Wetland	**Upland**	**Wetland**	**Upland**
T. canadensis occurrences	33	50	26	143
Wetland Frequency (%) Wetland Rating	39.8 [±8.5] FAC [FACU]		15.4 [±7.5] FACU [FACU]	
(b) Moderately-large (20,000 km^2)	**Boundary data**		**Landscape data (CRREL)**	
	Wetland	**Upland**	**Wetland**	**Upland**
T. canadensis occurrences	10	18	193	902
Wetland Frequency (%) Wetland Rating	35.7 [±15.1] FAC [FACU]		17.6 [±12.7] FACU [FACU]	

4 Discussion

These results suggest that Landscape data collected by using a large-scale study design are most appropriate for assigning wetland frequencies and ratings during NWPL challenges, regardless of whether they are collected for this purpose or obtained from an existing database. The Landscape data produced lower wetland frequencies and drier ratings (15%–18%, FACU) in both study areas, suggesting that *Tsuga canadensis* usually occurs in uplands but may occur in wetlands (Table 4). In contrast, Boundary data produced much higher wetland frequencies (36%–40%) and wetter ratings (FAC) in both study areas, suggesting that *T. canadensis* is equally likely to occur in wetlands and uplands. The Boundary and Landscape data were collected at different scales, reflecting different objectives, sample areas, plot sizes, and data recording methods. These factors determined the patterns detected in this study and also explain the large discrepancies in frequency. Two drawbacks were the relatively small sample size and the different methods used to collect data. Yet, overall, these differences suggest that the Landscape data produced the most accurate wetland frequencies because they reflect large-scale patterns of plant frequency, similar to those in the wetland frequency definition (Reed 1988). Boundary data produced less accurate wetland frequencies because they were collected at a small scale and do not reflect large-scale patterns of plant frequency as described in the definition of wetland frequency.

One explanation for the discrepancies in wetland ratings is that the Landscape and the Boundary data were collected to achieve different objectives and sample different populations. The Landscape data may be more accurate because they were collected based on large-scale objectives to collect vegetation data across the landscape. To meet this objective, the CRREL data were collected in all uplands and wetlands all across the landscape where *T. canadensis* might occur, such as wooded wetlands or upland forest (Magee and Ahles 2007). Areas such as herbaceous wetlands and dry, south or west facing slopes where it was unlikely to occur were excluded. Similarly, the NP data were collected in uplands and wetlands across National Park landscapes. Data were collected in all plant communities, including those in which *T. canadensis* was present. Therefore, all uplands and wetlands across the landscape where *T. canadensis* might occur were sampled. The scale of both investigations is similar to that of the definition of wetland frequency, which is based on large-scale concepts, such as a species’ range and its occurrence across the landscape (Reed 1988).

In contrast, the objective for collecting Boundary data was to determine if hydrophytic vegetation was present at a wetland boundary. Only areas adjacent to wetland boundaries were sampled to meet this small-scale objective. Sampling other locations in the landscape was not necessary given this objective. The accuracy of the wetland frequencies and ratings produced by these data is questionable because only a small portion of a species' range is sampled. For example, *T. canadensis* occurs in wooded swamps and lakeshores where wetland boundaries may be present (Hardin et al. 2001, 183–85; Gleason and Cronquist 1991; Magee and Ahles 2007). However, it also occurs in many other landscape positions where wetlands are usually absent, including rocky woodlands, hillsides, low ridges, slopes, and bluffs. These non-boundary upland habitats were not represented in the Boundary data. Thus, these data produced a much higher wetland frequency and a wetter rating when compared to the Landscape data (Table 4), which sampled all habitats where *T. canadensis* occurs.

Plot size may also contribute to discrepancies in wetland ratings. The Landscape data were collected by using large sample units (100 m transects and large plots), reflecting the large-scale study designs. The two differ in that CRREL transects were of uniform size so that *T. canadensis* had an equal probability of occurring on each one. The size of NP plots varied (Table 2). Frequencies derived from these data may be less reliable because plant frequency is highly dependent on plot size (Barbour et al. 1999; McCune and Grace 2002). For example, if a large plot is used to sample a given location, *T. canadensis* is recorded as present in that plot. However, the same plant may fall just outside a smaller plot (absent) used to sample the same location. A second difference is that CRREL transects were randomly located throughout the landscape to meet statistical assumptions regarding independence. NP plots were subjectively placed throughout the landscape (NC and Esri 1994), so it is possible that they were not independent. For instance, in a large wetland with several plant communities, *T. canadensis* might have been sampled more than once. If so, wetland frequency would be overestimated. Yet, both datasets produced the same rating (FACU) and very similar wetland frequencies (18% and 15%), suggesting that these differences had little effect on results (Table 4).

In contrast, the small-scale Boundary data appear to overestimate wetland frequency, for two reasons. First, the small-scale data-collection methods

obscure landscape-level patterns of plant occurrence. Boundary data were collected in fairly large plots that were placed adjacent to one another in a small sample area and on either side of the wetland boundary (Table 2). Under these circumstances, it is difficult to discern patterns of plant frequency because problematic plant species often occur on both sides of the wetland boundary (Lichvar and Gillrich 2014). Problematic species are likely to be present in both boundary plots (100% frequency), producing a wetland frequency of close to 50% and a hydrophytic (FAC) wetland rating (Olsen 2013) as seen in this study with *T. canadensis* (36%–40%, FAC). A second concern is that many delineation data forms did not include geographic coordinates for each pair of plots, so a wetland may have been sampled more than once. If so, wetland frequency would be overestimated.

One drawback to this meta-study is that data were obtained from several sources. Different data-collection methods may also explain the discrepancies between the wetland frequencies and ratings produced by the Landscape and Boundary data. The Landscape data that CRREL collected may have produced more accurate wetland frequencies because frequency was intensively sampled along transects, providing multiple opportunities for *T. canadensis* to be present or absent. Likewise, the Landscape data collected by NPS-USGS may have produced more accurate wetland frequencies because *T. canadensis* was counted as present every time it occurred, regardless of whether it was abundant or sparse. The Boundary data may have produced less accurate frequencies because *T. canadensis* was recorded as present only when it was abundant. Often only the dominant plant species in a plot are recorded on the delineation datasheet (Environmental Laboratory 1987). Dominant species, those with the largest percent areal cover values in each vegetative stratum, are selected using the 50/20 Rule (USACE 2012). Non-dominant species with lower cover values are typically disregarded. Other work has shown that the use of select dominant species, instead of all species in a plot, creates biased vegetation determinations (Lichvar et al. 2011; Gillrich et al. 2011; Lichvar and Gillrich 2014). This selective recording of dominant species likely affects wetland frequency calculations derived from Boundary data. Although a comparison of data collected using different methods is not ideal, this exploratory effort provided valuable insights into potential methods, scales, and methods for future challenges to the NWPL. The wetland ratings and frequencies produced are considered experimental.

A final concern is that the sample size of these datasets was limited by difficulties obtaining data. Sample size was fairly low, and the maximum possible error was high for all frequency calculations. The Boundary data were fairly numerous in both study areas (42 and 134). They were also surprisingly difficult to obtain. In states such as Michigan and New Hampshire that have assumed much of the responsibility for the Section 404 wetland program, delineation data forms are maintained by the state. The Corps cannot easily access them. In other states, Corps Districts store data forms either on microfiche or as electronic files on computers. But computerized searches by plant species or wetland type are not possible because biological data are often hand written. In contrast, sample size in the Landscape data was limited by the labor-intensive nature of field sampling (CRREL data) and record clarity (NP data). Although intensive, point-intercept sampling increases accuracy; it does not increase sample size (n = 36), making it impractical across large study areas, such as a Corps region. In addition, in remote sampling locations, *T. canadensis* was often absent. Under these conditions, the cost of field sampling was far greater than its benefits. In the NP data, sample size was limited by record clarity. Although the number of plots (169) was fairly large, 90 additional plots were excluded from this study because they could not be confidently classified as wetland or upland. This problem is likely to occur with any data that was not collected for the purpose of determining wetland frequency. However, the U.S. Forest Service also collects landscape-level frequency data for inventory and monitoring purposes. When considered together, data collected by the NPS and the Forest Service may provide the large sample sizes (≅400) necessary to achieve a confidence interval of 95% and the 3%–5% margin of error suggested by the NTCWV.

5 Conclusions

Although data collected during wetland boundary delineations appear to provide a readily available, cost-effective method to calculate wetland frequency and to assign ratings to problematic species during challenges to the NWPL, they should not be used for these purposes. These results suggest that Boundary data produce much higher frequencies and wetter ratings when compared to data that were collected across the landscape. Inaccuracies may be caused by (1) sampling just one landscape position rather than all habitats where a species occurs; (2) recording only dominant species on delineation datasheets; and (3) using large, adjacent plots that are statistically likely to yield a FAC rating. A final concern is that wetland delineation data sheets are difficult to obtain both from regulatory agencies and from public sector environmental consulting firms.

When ratings of problematic species cannot be resolved using literature references, herbaria records, and the best professional judgment of botanists and ecologists, calculating wetland frequency by using data collected with large-scale sampling methods designed to assess wetland frequency may provide more information on a species occurrence. Using tested and published protocols (Gage et al. 2016) as a guide, NTCWV will work with challengers to formulate a sampling design at a scale relevant to the species being challenged. The NTCWV may also approve use of data from existing databases, such as that of the National Park Service, as the results of this study suggest that they produce the same wetland rating and similar frequencies when compared to data collected across the landscape for the purpose of assessing wetland frequency.

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14. ABSTRACT
This study examined two types of data for determining a species' wetland frequency and rating during rating-change-request challenges to the National Wetland Plant List (NWPL). *Tsuga canadensis* (L.) Carr., a species with a problematic wetland rating, was used as a case study. *Boundary* data were collected on wetland boundaries during delineations by Corps regulators and private consultants, and *Landscape* data were collected across the landscape during vegetation research projects by the Cold Region Research and Engineering Laboratory team. This investigation compared the wetland frequencies and ratings produced by Boundary data and Landscape data across a large and a moderately large study area. In both study areas, the Boundary data produced a higher wetland frequency (36%–40%) and a wetter wetland rating (Facultative—FAC) than the Landscape data (15%–18%, Facultative Upland—FACU). These results demonstrate why wetland delineation data should not be used for determining wetland frequency and ratings during challenges to the NWPL because (1) they do not represent a species' entire distribution across the landscape; (2) only dominant species are recorded on delineation data forms; (3) large, adjacent boundary plots are statistically likely to produce a FAC rating; and (4) delineation data are difficult to access from both regulatory agencies and public sector environmental consulting firms.

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